Draft Final Options for Preparing Delaware for Sea Level Rise

The following list of Options for Preparing Delaware for Sea Level Rise was developed by Delaware's Sea Level Rise Advisory Committee for potential inclusion into the State's Sea Level Rise Adaptation Plan. The options below were the result of an October 2012 workshop, discussions with subject matter experts and deliberation by the Advisory Committee. The options target the 16 vulnerable resources that were considered a high or moderate concern in the 2012 Sea Level Rise Vulnerability Assessment for the State of Delaware.

The options below have been modified from the February, 2013 list to incorporate public comments as discussed at the 4/26/2013 meeting of the Sea Level Rise Advisory Committee. For consistency, all options have retained the original numbering system but will be re-numbered in the Adaptation Plan.

These Options are expected to be finalized by the SLRAC at it 5/23/2013 meeting. Once finalized, they will become recommendations from the committee to DNREC Secretary Collin O'Mara, included in the Adaptation Plan for the state and used as a roadmap for implementation activities.

Improve Communication and Coordination between State, Federal, Local and Regional Partners to Streamline Sea Level Rise Adaptation Efforts

1. **Conduct a comprehensive inventory of key funding, coordination, regulations and policies and analyze them for barriers and opportunities for sea level rise adaptation:** Many recommendations of the Sea Level Rise Advisory Committee propose changes that would remove obstacles for adaptation and increase coordination amongst agencies. However, many other barriers and opportunities may exist that were not able to be considered within the time frame of the Committee's work. A comprehensive study of key funding, coordination, regulation and policies could help shed light on opportunities for coordination and removal of barriers that had not previously been considered. Private sector plans could also be considered and incorporated.
    a. **Vulnerabilities Addressed: All**
    b. **Adaptation Options Addressed: Accommodate, Avoid, Protect, Retreat**

2. **Increase opportunities for technology transfers and regional coordination for transportation issues affected by sea level rise.** Delaware, Maryland, Pennsylvania and New Jersey have an integrated road, bridge and railway system that will require coordination and cooperation between the states and the US Department of Transportation to adequately address sea level rise. Using existing professional venues, such as regional Metropolitan Planning Organizations (MPOs), and the American Association of State Highway Transportation Officials (AASHTO), DelDOT should integrate this new dimension into its planning, design, and operation policy discussions and standards development. .
    a. **Vulnerabilities Addressed: Roads and Bridges, Rail**
    b. **Adaptation Options Addressed: Accommodate, Avoid, Protect, Retreat**

4. **Improve coordination of permit decisions for adaptation projects between federal, state and local officials.** Permitting processes that involve several different agencies, particularly those for transportation, sewer infrastructure, shoreline protection and commercial or residential developments can be delayed when agencies lack a common set of goals or have conflicting regulatory requirements. As sea level rise adaptation becomes incorporated into project proposals, conflicting regulations may delay permitting processes. Early coordination of

projects between state, federal and local officials could help minimize regulatory conflicts and delays as would incorporation of sea level rise consideration into regulatory decisions. These actions may lead to more rapid issuance of permits for adaptation projects, more predictability for applicants and an increased predictability and empowerment for local governments when planning and design their own adaptation projects.

   a. **Vulnerabilities Addressed: Roads and Bridges, Wetlands, Residences, Beaches and Dunes, Wastewater Treatment Facilities, Dikes and Levees**
   b. **Adaptation Options Addressed: Protection, Accommodation**

5. **Incorporate sea level rise into public and private sector regional planning efforts.** Much of Delaware's infrastructure is part of a regional network, including electrical generation, roads, rail, and landfills. Delaware's wetlands, habitats of conservation concern, beaches and nature preserves are also part of a regional system of wildlife and fish habitats. Incorporation of a common set of sea level rise information into regional planning processes for these resources will help ensure that informed decisions about adaptation are made and that the entire regional system is sustainable. Regional planning processes that should be targeted include: Wilmington Area Planning Council's and Dover/Kent Metropolitan Planning Council's long range plans for transportation, Amtrak long range plans, business groups and industry contingency plans, and regional habitat plans.
   a. **Vulnerabilities Addressed: Roads and Bridges, Evacuation Routes, Habitats of Conservation Concern, Railroad Lines, Wetlands**
   b. **Adaptation Options Addressed: Accommodate, Avoid, Protect, Retreat**

6. **Create new partnerships to increase resources for research and development of adaptation options.** New and innovative solutions may exist for adaptation to sea level rise, including new shoreline stabilization methods, wave attenuation structures or oyster reefs, and offshore structures. Pilot projects to determine the efficacy of untested techniques may yield positive results. Forming new partnerships or strengthening existing partnerships with neighboring states, federal agencies, the consulting community, universities, and non-profits will greatly expand the knowledge and funding available for research and development. Collaboration can expand regional sediment management research and opportunities for beneficial reuse of dredged spoil.
   a. **Vulnerabilities Addressed: All**
   b. **Adaptation Options Addressed: Accommodate, Protect**

7. **Provide sea level rise information to the Delaware Agricultural Land Preservation Program for consideration.** The Agricultural Land Preservation Program protects land for agricultural purposes through voluntary measures. Included among these are the purchase of preservation easements which permanently protect farmland from development while allowing agricultural uses to continue. High quality soils, significant agricultural infrastructure, historical and environmental significance are all factors that have been considered in program eligibility.
   a. **Vulnerabilities Addressed: Agricultural Land Conservation Easements**
   b. **Adaptation Options Addressed: Avoid**

8. **Provide technical assistance to Delaware's Open Space Council for incorporating sea level rise into its criteria for acquisition of natural areas.** Delaware's Open Space Council works to secure the permanent protection of open spaces in Delaware including parklands, forests, fish and wildlife areas, nature preserves and cultural sites. The Open Space Council has developed criteria that it uses to prioritize and assess potential land

purchases. Sea level rise has been included in these criteria, but additional assistance may be necessary to refine and modify the criteria.

a. **Vulnerability Addressed: Nature Preserves, Protected Lands Statewide**
b. **Adaptation Options Addressed: Avoid, Retreat**

Provide Increased Regulatory Flexibility for Adaptation and Improve Consistency between Regulatory Agency Decisions

10. **Encourage early transportation planning and conceptual infrastructure design for sea level rise adaptation.** To help Delaware maintain an efficient and effective transportation network, DelDOT should initiate a planning level analysis for inevitable infrastructure replacement due to sea level rise and extreme weather events. Where there are predictable impacts to critical roadway infrastructure (large bridges, causeways, evacuation routes, etc.) due to sea level rise, DelDOT should initiate conceptual designs to identify impact locations and define a strategy to deal with those impacts in advance. This will allow DelDOT to determine the basic type, size, and location of infrastructure needing upgrade or replacement before the occurrence of sea level rise and extreme weather events that would place that infrastructure at risk of damage or failure. It will also allow for the development of an environmental permitting and cultural resources approval strategy for each location based on site specific characteristics. The conceptual design and permitting strategy would constitute DelDOT's sea level rise adaptation plan for each location. Those plans would be implemented at an appropriate time based on need and funding availability. As sea level rise is anticipated to extend over a long period of time, DelDOT should periodically update the adaptation plan for each location – accounting for updated sea level rise predictions, updated state or regional plans, and changing rules and regulations affecting project delivery.
    a. **Vulnerability Addressed: Roads and Bridges, Evacuation Routes**
    b. **Adaptation Option Addressed: Accommodate, Avoid, Retreat**

11. **Allow for the connection of individual septic systems to community septic systems with excess capacity when human safety and welfare are at risk.** The Sea Level Rise Vulnerability Assessment identified over 3,000 septic systems at risk of inundation in Delaware – many of these could begin to fail prior to inundation due to increasing water tables. Although it is possible to provide central sewer service to residents with failing septic systems, in some cases it is not economically feasible to do so. In these cases, it may be feasible to connect failing septic systems to nearby community septic systems that have excess treatment capacity. This would allow systems failing due to sea level rise to connect to a treatment facility as an interim measure that may expand the lifespan of a residence in a vulnerable area. An agreement would have to be made between the individual landowner and the operator of the community system. It is unknown at this point if the costs would be the sole responsibility of the landowner or if existing grant and loan programs could be utilized to defray costs. There is concern that allowing connection to community systems could foster residential growth in vulnerable areas.
    a. **Vulnerability Addressed: Septic Tanks and Disposal Fields**
    b. **Adaptation Option Addressed: Accommodate**

13. **Consider sea level rise implications in future regulatory updates for septic systems and wells.** Sea level rise and its associated impacts, such as increased flooding, rising water table, and salt water intrusion, can reduce or eliminate the functionality of on-site wastewater treatment systems and groundwater wells. Permit criteria for the siting, design, and construction of wastewater disposal systems and wells are specified in state regulations. Incorporating sea level rise considerations into future updates of these regulations to implement protective design and siting requirements could reduce vulnerability of these systems and wells to the effects of sea level rise. Additional studies of sea level rise implications for Delaware's groundwater would be necessary before criteria could be developed. The costs of any additional requirements should be carefully considered and weighed against the lifespan of the system.
    a. **Vulnerability Addressed: Wells, Septic Systems and Disposal Fields**
    b. **Adaptation Option: Accommodate, Avoid**

14. **Encourage the governor to sign an executive order that would direct state agencies to plan for sea level rise.** The vulnerability assessment demonstrates that sea level rise has consequences throughout the state and to a wide variety of resources. Adapting to sea level rise at the state level will require state agencies to work together using a consistent set of data and predictions. An executive order could direct each state agency to conduct an agency specific vulnerability assessment using a common set of future scenarios. It could also direct each agency to consider future sea levels in the design of state projects and infrastructure, identify adaptation plans for state owned assets, and to identify regulatory and policy opportunities and barriers.
    a. **Vulnerability Addressed: All**
    b. **Adaptation Options: Accommodate, Avoid, Protect, Retreat**

15. **Provide regulatory incentives that encourage sea level rise adaptation and that allow for innovative projects.** Sea level rise is an emerging issue for which many state and local regulations do not yet consider. A variety of adaptation measures from raising buildings to protecting shorelines may not be permissible or may take longer to permit than measures which do not include sea level rise considerations, setting up a perverse incentive that could result in no adaptation or maladaptation. Local and state regulations and building codes should be assessed for opportunities to provide incentives for adaptation, particularly for demonstration projects. As an example, the Delaware Department of Natural Resources and Environmental Control recently issued a "Statewide Activity Approval" for shoreline stabilization projects that incorporate natural and planted marshes. Under this approval, average permitting times for these projects will be reduced to one to two weeks.
    a. **Vulnerabilities Addressed: Wells, Septic Systems, Residences, Wetlands, Beaches and Dunes**
    b. **Adaptation Options Addressed: Protection, Accommodation, Retreat**

16. **Consider sea level rise implications in future updates to the state Coastal Zone Act regulations.** Delaware's Coastal Zone Act prohibits new heavy industrial uses in the coastal zone and requires permits and environmental offset projects for modifications to existing heavy industrial facilities. Existing heavy industry in the coastal zone is very important to Delaware's economy; these facilities should be allowed the flexibility to adapt to sea level rise. Sea level rise considerations, including the potential future need for shoreline improvements, drainage improvements and facility upgrades, should be included in any future regulatory updates.
    a. **Vulnerabilities Addressed: Heavy Industrial Areas**
    b. **Adaptation Options Addressed: Protection, Accommodation**

17. **Create a financial assurance program to minimize the state's liability to clean up industrial sites if they are abandoned as a result of sea level rise.** The Vulnerability Assessment indicated that up to a quarter of the state's heavy industrial areas could be inundated by sea level rise. This could result in abandonment of industrial properties that could lead to contaminated soils. If the responsible company cannot be held liable for the cleanup due to bankruptcy or other factors, the responsibility of cleaning up the site would lie with the state. Creation of a financial assurance program would ensure a designated funding stream for cleanup of these sites and provide certainty to both the state and businesses about the process to follow in the event of abandonment of an industrial site.
    a. **Vulnerabilities Addressed: Heavy Industrial Areas**
    b. **Adaptation Options Addressed: Retreat**

18. **Conduct a comprehensive update to the state's regulatory tidal wetlands maps and provide a way to periodically update the maps to reflect changes occurring from sea level rise.** Activities in tidal wetlands are regulated by the state through its Wetlands Act (Del Code 7, chapter 66). Wetlands were inventoried and drawn on maps and any tidal wetland depicted on this map is regulated by the state. However, the aerial photographs for these maps were flown in 1988 and have not been comprehensively updated since that time. Sea level rise, erosion and coastal storms cause wetlands to migrate and the existing maps may no longer be accurate. The Vulnerability Assessment concluded that 99% of the state's existing tidal wetlands could be inundated by sea level rise – comprehensively updating the regulatory wetland maps on a routine basis will help protect tidal wetland areas that migrate inland.
    a. **Vulnerabilities Addressed: Tidal Wetlands**
    b. **Adaptation Options Addressed: Accommodate, Retreat**

Provide Consistent and Predictable Policies for Future Growth, Investment, and Natural Resource Management

19. **Incorporate sea level rise considerations into the Strategies for State Policies and Spending.** Land-use decisions in Delaware are made at the local level, but the bulk of infrastructure and service that support these decisions are funded by the state. The Strategies for State Policies and Spending set forth clear advisory policies (including maps) about where the state will allocate financial resources for conservation, infrastructure improvements and social services. The Strategies are updated every five years. Incorporation of sea level rise into the suite of issues considered during the update process would provide opportunity for coordination between agencies and local governments regarding sea level rise and may help further ensure wise use of state funding.
    a. **Vulnerabilities Addressed: Future Development Areas, Road and Bridges, Protected Lands**
    b. **Adaptation Options Addressed: Accommodate, Avoid, Protect, Retreat**

20. **Incorporate sea level rise considerations into municipal comprehensive development plans.** State law requires that every municipality in Delaware develop, and periodically update, a comprehensive development plan. These plans contain a municipal development strategy that includes expansion of boundaries, future plans for residential and commercial growth, and future infrastructure investments, among others. It also contains environmental and demographic information. Requiring the plans to include a discussion of potential sea level rise impacts and potential adaptation actions would ensure that all municipalities in the state were proactively

considering sea level rise in their future plans for growth and development and may allow for increased communication about sea level rise between municipal, county and state governments.

a. **Vulnerabilities Addressed: Future Development Areas**
b. **Adaptation Option Addressed: Accommodate, Avoid, Retreat, Protect**

21. **Incorporate sea level rise into Delaware's Long Range Transportation Plan (LRTP).** Delaware's Long Range Transportation Plan serves as a strategic planning tool for the state to chart the course of transportation for the next 20 years. Including sea level rise in the evaluation of transportation needs, and as a particular statement in the plan, will provide the necessary policy support for DelDOT to incorporate sea level rise into project planning and establish a framework for directing investments and identify financial resources to sustain the plan's vision.
    a. **Vulnerabilities Addressed: Roads & Bridges, Evacuation Routes**
    b. **Adaptation Options Addressed: Accommodate, Avoid, Retreat, Protect**

22. **Incorporate sea level rise into the Transportation Operations Management Plan.** Future updates to DelDOT's Transportation Operations Management Plan (TOMP) for each county should consider impacts to the safe and efficient operation of the state's roadways and evacuation route planning due to sea level rise.
    a. **Vulnerabilities Addressed: Roads & Bridges, Evacuation Routes**
    b. **Adaptation Options Addressed: Accommodate, Avoid, Retreat, Protect**

23. **Encourage inclusion of sea level rise in Transportation Project Design Manuals.** To ensure consistency of highway infrastructure across the country, national standards are cooperatively developed by state Department of Transportations and the Federal Highway Administration under the banner of the American Association of State Highway and Transportation Officials (AASHTO). These adopted standards cover all aspects of design and road geometry, as well as signals, signs and markings. These standards need to be updated to reflect the predicted effects of sea level rise on such long-lived assets such as roadways and bridges, accounting for differences in sea level rise scenarios in different areas of the nation.
    a. **Vulnerabilities Addressed: Roads & Bridges, Evacuation Routes**
    b. **Adaptation Options Addressed: Accommodate, Avoid, Retreat, Protect**

24. **Develop a statewide retreat plan.** There are certain locations within the state where "retreat" may be the best adaptation strategy, including some natural areas, agricultural areas and developed areas where protection may not be feasible due to expense or engineering constraints. There is a desire from businesses, citizens and state agencies to have predictability in adaptation responses so that they can make long term plans. A statewide plan outlining areas where retreat may be the most appropriate adaptation option would allow state agencies to put lifespan limits on infrastructure in vulnerable areas, allows targeted land acquisition for inland migration of wetlands and shorelines, and would provide predictability for citizens. Significant new data about adaptation costs, shoreline responses to sea level rise and demographic information would be required before a retreat strategy could be researched and crafted. Any retreat plan would also require significant dialogue with elected officials and citizens.
    a. **Vulnerabilities Addressed: All**
    b. **Adaptation Options Addressed: Retreat**

25. **Conduct a legal review for disinvestment of publically owned infrastructure and privately owned buildings.** Retreat is an important strategic option for dealing with sea level rise. Many private and public buildings and

other infrastructure, such as roads, may become impractical to maintain as the environment changes and will be abandoned. There are many public health and safety implications that must be addressed, such as removal of contaminants, as well as legal implications, such as loss of access to a property or loss of property value due to removal of an inter-related public or private asset. In addition, there are also equal protection and environmental justice implications for low income and/or minority communities that could be affected by disinvestment. A review of the legal framework – especially real estate and environmental law – will be needed in order to begin to understand the legal feasibility as well as true costs and consequences of a retreat strategy.

a. **Vulnerabilities Addressed: Roads & Bridges, Septic Systems, Residential Areas, Wastewater Facilities**
b. **Adaptation Options Addressed: Retreat**

26. **Consider use of a Transfer of Development Rights tool to direct future growth away from vulnerable areas.** A Transfer of Development Rights (TDR) tool helps to direct future growth away from vulnerable areas by allowing for increased densities in areas more appropriate for development. This could help to ensure future growth needs are met, but by utilizing land outside of potentially vulnerable areas. TDRs have been used by County governments to direct residential and commercial growth away from agricultural areas, but their use is not yet widespread.
    a. **Vulnerabilities Addressed: Future Development Areas**
    b. **Adaptation Options Addressed: Avoid**

27. **Develop a dike safety program.** There are numerous dikes throughout the state which act to protect infrastructure, natural resources and private property from flooding during storms and extreme high tides. However, there is no one entity in charge of inspecting, maintaining and improving these dikes. The dikes are also owned by a variety of different entities, which confounds their management and upkeep. The creation of a Dike Safety Program would ensure a single point of contact for dike repairs and management. It could also be responsible for conducting feasibility studies for improving or abandoning dikes and obtaining funding for repairs and upgrades. A similar program has recently been implemented for dams within the state. Creation of such a program may require new legislation.
    a. **Vulnerability Addressed: Dikes & Levees**
    b. **Adaptation Options Addressed: Accommodate, Protect**

28. **Designate shoreline zones for adaptation action.** Shoreline protection and restoration projects require federal, state and sometimes local permits. Hardening of shorelines (bulkheads or riprap) is generally discouraged by state policies, but may be the most appropriate adaptation response in urban or industrial areas. Conversely, soft or "living" shorelines may be the most appropriate in rural or environmentally sensitive areas. Criteria for shoreline adaptation would have to be based on peer reviewed literature and done in collaboration with stakeholders. Planning for and designating areas statewide where shoreline hardening will be allowable, where hardening would be discouraged, and where living shorelines will be encouraged will provide certainty for permit applicants and may streamline the permitting process. These designations should also be incorporated into appropriate federal, state and local permitting processes
    a. **Vulnerability Addressed: Beaches and Dunes, Wetlands, Industrial Areas, Residences, Businesses**
    b. **Adaptation Options Addressed: Accommodate, Protect**

29. **Develop comprehensive wetlands restoration strategy in response to sea level rise.** A comprehensive wetlands restoration strategy for the state is necessary given the anticipated impacts from sea level rise. The strategy should include identification of uplands for preservation and acquisition to provide areas for marsh migration; preventing the construction of structures that would act as barriers to migration; wetland restoration techniques to allow wetlands to keep pace with sea level rise; cataloging of pertinent research needs; policy and regulatory changes; and an outreach strategy. Specific ideas that could also be incorporated include-evaluating phragmites control techniques, beneficial re-use of sediment, and rolling easements.
    a. **Vulnerabilities Addressed: Wetlands, Coastal Impoundments**
    b. **Adaptation Options Addressed: Accommodate, Retreat**

30. **Continue efforts to re-evaluate management strategies for existing coastal impoundments.** The state's Division of Fish and Wildlife and the US Fish and Wildlife Service own and operate coastal impoundments in the state which provide bird habitat, fish nursery grounds, and flood abatement. In recognition that current management practices for impoundments may be unsustainable in light of sea level rise, the Division of Fish and Wildlife has begun research and planning to improve impoundment management and develop adaptation strategies. Future management strategies could consider incorporating beneficial re-use of dredge disposal sediments to build up elevation and possibly adjusting locations of impoundments after considering the landscape and resource needs. Lessons learned from pilot projects and new management techniques should be shared with the US Fish and Wildlife Service and others throughout the region who also manage impoundment structures. Outreach to surrounding communities about any changes to impoundment management should also be considered.
    a. **Vulnerability Addressed: Coastal Impoundments**
    b. **Adaptation Options Addressed: Accommodate, Protect, Retreat**

31. **Evaluate the benefits and risks of permitting privately owned coastal impoundments.** The Vulnerability Assessment found that virtually all of the state's coastal impoundments are vulnerable to sea level rise. These areas provide important breeding, migration and wintering habitat for birds and serve as nursery grounds for fish. Construction of coastal impoundments in state regulated tidal wetlands is rarely approved due to a variety of natural resource concerns, habitat management issues and impacts to surrounding landowners. However, in light of potential losses of existing large impoundments, providing similar alternatives at a smaller scale can provide beneficial habitat if impoundments are properly managed. An endowment could be required for any new impoundment to ensure future maintenance and conservation easements, which would provide permanent protection to the land and direct management practices, should also be required. Impacts to local hydrology, mosquito control, flooding and drainage issues and potential liabilities will need to be evaluated prior to permitting new impoundments on private land
    a. **Vulnerability Addressed: Coastal Impoundments**
    b. **Adaptation Options Addressed: Accommodate, Retreat**

32. **Develop a framework for decision making regarding land protection and restoration strategies based on habitat vulnerability, migration potential and relative importance in the regional landscape, historical significance or other key factors.** In order to prioritize land acquisition and protection strategies in light of sea level rise impacts, a decision tree, process model, cost/benefit analysis, or similar tool is needed. The U.S. Geological Survey is developing a computer model to prioritize habitat types for the northeast region. Upon completion, this model may assist in determining priority needs that consider a broader, regional context.

Consideration should also be given to the ecological services provided by these lands and economic values be placed on them. Land acquisition should be aggressively targeted for the highly ranked habitat types.

a. **Vulnerability Addressed: Habitats of Conservation Concern, Nature Preserves, Wetlands, Protected Lands**
b. **Adaptation Options Addressed: Accommodate, Protect, Retreat**

Increase Public Awareness of Sea Level Rise through Education, Outreach and Marketing

33. **Develop a comprehensive outreach strategy to educate public about sea level rise.** A comprehensive outreach strategy should be developed to increase Delaware's understanding of sea level rise and how it may potentially affect many aspects of life in this state as well as the ways to reduce these impacts. A strategy may include collection of input about the best way to reach different audiences. Education efforts should include both year round and seasonal residents, children, government officials, businesses, farmers, real estate agents, insurance agents, utilities and industries so informed decisions can be made in the future. Increased education would engage more agencies and funding sources and may result in support that can help integrate sea level rise in long-term management plans, acceptance of the management decisions made, and possibly influence legislative decision making. Providing information about other successful sea level rise programs and initiatives may further assist in Delaware's acceptance of sea level rise and successful ways that impacts were mitigated through adaptation strategies.

a. **Vulnerability addressed: All**
b. **Adaptation options addressed: Accommodate, Avoid, Protect, Retreat**

34. **Provide education and outreach for impacted communities and citizens.** Communities that may be the most impacted by sea level rise should be provided with up-to-date information on sea level rise scenarios and be informed of adaptation measures that can reduce the impacts of sea level rise on their homes and communities. Residents of these areas should be made aware of where to go for information about differences between long-term and short-term adaptation measures, benefits and risks of adaptation measures, the combination of risk factors that exist together (drainage and stormwater, coastal storms and sea level), and changes occurring in the insurance industry that may impact insurance availability and cost.

a. **Vulnerability addressed: All**
b. **Adaptation options addressed: Accommodate, Avoid, Protect, Retreat**

a. **Improve the ability of homebuyers to investigate a property's potential vulnerability to sea level prior to purchase.** Homebuyers' access to information about future sea levels should be improved through development of a comprehensive website that illustrates current flooding and future sea level rise inundation risks. In addition, prospective homeowner understanding of flood risks should be increased through increased interactions with local city planners. For example, the City of Newark has a successful program where prospective homeowners meet with land use planners prior to purchase to review the property and surrounding land uses. A similar model could be employed in other municipalities and could include sea level rise information. **Vulnerability Addressed: Residential Areas**
b. **Adaption Options Addressed: Accommodate, Avoid, Protect, Retreat**

36. **Provide targeted outreach to water and wastewater operators and water utilities:** Opportunities exist to reach out to state, municipal, county and private water and wastewater professionals at annual conferences of water associations, such as the Delaware Rural Water Association and the Delaware Onsite Wastewater Recycling Association. These conferences are key venues for disseminating information on sea level rise, engaging stakeholders and experts in planning for impacts, and evaluating preferred adaption options and strategies to meet long term goals.
    a. **Vulnerability addressed: Wastewater Facilities, Septic Systems, Wells, Residential Areas, Future Residential Areas, Heavy Industrial Areas**
    b. **Adaption options addressed: Accommodate Avoid, Protect, Retreat**

Improve the Availability & Robustness of Sea Level Rise Data Sets:

37. **Conduct a risk assessment for Delaware's system of dikes & levees. Dikes and levees act to** protect infrastructure, natural resources and private property from flooding during storms and extreme high tides. An inventory of the dikes and levees in the state should be conducted to determine which ones are most at risk, including an specific analysis for each dike of future risks posed by sea level rise and stormwater concerns This would lead to a risk analysis to evaluate if there is an escalating risk from the projected sea level rise scenarios discussed in the Vulnerability Assessment.
    a. **Vulnerabilities addressed: Dikes and Levees, Heavy Industrial Areas, Landfills, Railroad Lines, Future Development Areas, Residential Areas, Evacuation Routes, US Fish and Wildlife Property, and Habitats of Conservation Concern**
    b. **Adaptation options addressed: Accommodate, Protect**

38. **Develop and maintain a comprehensive database that contains the location and condition of all wastewater infrastructure.** The Vulnerability Assessment analyzed public wastewater facilities and pumping stations however, data layers regarding private or community systems, pumping stations and pipelines are not available in a consolidated format. This information should be entered into a comprehensive database and routinely updated to more accurately plan for sea level rise impacts to wastewater systems and to identify opportunities to integrate services in vulnerable areas to systems that may be more reliable over time. The database should include a conditions assessment of the facility in order to plan for anticipated maintenance and upgrades. It should also triage areas for repairs and relocation to expedite the process when funds are available.
    a. **Vulnerabilities addressed: Wastewater Facilities, Septic Systems, Heavy Industrial Areas, Future Development Areas, Residential Areas, Tourism and Coastal Recreation, Port of Wilmington.**
    b. **Adaptation options addressed: Accommodate Avoid, Protect, Retreat**

39. **Identify data needs to plan transportation investments.** Roads and bridges that are located in areas that are expected to have flooding issues as illustrated through the inundation models in the Vulnerability Assessment should be specifically identified Routes should then be prioritized based on: system performance, age and condition, lifespan, origin and destination, replacement schedule, adjoining land use (both present and future), and choke points. Sea level rise inundation scenarios should be incorporated into the existing mechanisms DelDOT uses to prioritize projects.

a. **Vulnerabilities addressed: Evacuation Routes, Roads and Bridges, Tourism and Coastal Recreation, Future Development Areas, Residential Areas**
b. **Adaptation options addressed: Accommodate Avoid, Protect, Retreat**

40. **Model potential stormwater inundation problems in highly vulnerable areas.** Sea level rise may reduce the ability of stormwater to drain from an area if the outfalls are located on tidal waterbodies or are linked to tide gates. This can exacerbate flooding effects that occur from heavy rainfall events and storm surge. Watershed scale or smaller models should be developed for a better understanding of flooding impacts from the combination of stormwater and increased tides.
    a. **Vulnerabilities addressed: Dikes and Levees, Heavy Industrial Areas, Landfills, Future Development Areas, Residential Areas, Evacuation Routes**
    b. **Adaptation options addressed: Accommodate Avoid, Protect, Retreat**

41. **Develop a model that will predict changes to salinity in surface water that may occur under differing sea level rise scenarios.** Improving our understanding of sea level rise impacts from the changes to the extent of the salt wedge in the Delaware River is necessary to better assess risk to infrastructure, facilities and natural systems. Modeling can provide information necessary to better anticipate impacts to natural systems and develop an understanding of the different threshold of these systems. This could be done on a smaller watershed scale using nested models.
    a. **Vulnerabilities addressed: Heavy Industry Areas, Port of Wilmington, Tidal and Freshwater Wetlands, Habitats of Conservation Concern, US Fish and Wildlife Property, Agricultural Land Conservation Easements**
    b. **Adaptation options addressed: Accommodate Avoid, Protect, Retreat**

    a. **Develop a statewide groundwater model.** A general, screening-level groundwater computer model can provide information on how sensitive groundwater movements and water table levels may be impacted by sea level rise. This data would provide the necessary information needed to understand which industries and businesses may be at risk from corrosion, which contaminated sites may be at risk, and which habitats may be threatened as well. Assessment may need to occur on a site specific basis, but an improved understanding of sea level rise impacts to the water table is necessary to better assess risk.
    Vulnerabilities addressed: All
    b. **Adaptation options addressed: Accommodate, Avoid, Protect, Retreat**

43. **Encourage the development of a research and policy center at a university or college campus that would focus on applied research for sea level rise and adaptation.** There are many regional data gaps about sea level rise. Filling these gaps in our knowledge through collaboration with networks of university researchers and policy analysts would improve adaptation planning efforts. It may be worthwhile to incentivize university researchers to address these topics. Developing clear statements of research needs may improve the academic community's ability to obtain grant funding for research.
    a. **Vulnerabilities addressed: All.**
    b. **Adaptation options addressed: Accommodate Avoid, Protect, Retreat**

44. **Improve monitoring of current sea level conditions and improve predictions for timing of inundation.** The number of monitoring stations should be expanded to improve the sea level rise data that is currently being

collected. Increasing the number of tide gauges along the coast of Delaware would provide more continual monitoring to ensure model projections incorporate most recent rates of change and would improve our understanding of potential risks on a finer scale. Increased monitoring should include more information on changing landscapes including agricultural lands and wetland areas.

a. **Vulnerabilities addressed: All.**
b. **Adaptation options addressed: Accommodate, Avoid, Protect, Retreat**

45. **Increase understanding of the regional implications of loss of industrial areas in coastal Delaware.** Reduction in capacity at power generating facilities and ports may have regional implications for the electrical grid as well as availability of goods and services. In order for businesses to make wise decisions about future investments in their coastal industrial properties, additional information will be needed about impacts to other facilities throughout the region.
    a. **Vulnerabilities addressed: Dikes and Levees, Heavy Industrial Areas, Port of Wilmington, Railroad Lines, Future Development Areas, Evacuation Routes**
    b. **Adaptation options addressed: Accommodate Avoid, Protect, and Retreat.**

46. **Improve understanding of impacts to adjacent properties from adaptation actions.** Certain adaptive measures taken to mitigate the impacts of sea level rise may have unforeseen secondary and cumulative impacts to adjacent properties. For example, the hardening of a segment of shoreline with rock can result in accelerated erosion of adjacent unprotected shorelines. Understanding the complex impacts of various adaptive measures will help guide more effective adaptive response plans.
    a. **Vulnerabilities addressed: All**
    b. **Adaptation options addressed: Accommodate, Avoid, Protect, Retreat**

47. **Develop sea level models that incorporate storm surge impacts.** Sea level rise can exacerbate the effects of storm surges. The current sea level rise Vulnerability Assessment is based on a bathtub model, where the extent of inundation is estimated based on mean higher high water and elevation. The bathtub model does not yet incorporate storm surges due to the complexity of accurately modeling storm surge at a statewide level. . However, a storm surge model that takes into account future sea levels would provide a tool to better plan for inundation impacts.
    a. **Vulnerabilities addressed: All**
    b. **Adaptation options addressed: Accommodate Avoid, Protect, Retreat**

48. **Foster pilot projects that demonstrate the effectiveness of best management practices for management of agricultural lands affected by sea level rise.** Pilot projects to demonstrate or to study the effectiveness of best management practices could be used to provide technical guidance assistance to land managers to better adapt to sea level rise. These projects would provide insight on the effectiveness of the adaptation strategy and provide information on the associated costs.
    a. **Vulnerabilities addressed: Agricultural Land Conservation Easements, Protected Lands Statewide, Habitats of Conservation Concern**
    b. **Adaptation options addressed: Accommodate Avoid, Protect, Retreat**

49. **Identify and preserve areas for potential wetland migration.** As coastal wetlands become permanently inundated, it is vital to facilitate the landward migration of these habitats to maintain their valuable functions.

Available geographic information system (GIS) data layers can help identify lands adjacent to wetlands which have the potential to accommodate future marsh migration. Criteria should also be developed to prioritize lands for acquisition or permanent conservation easements. As an example, areas that are undeveloped or lack barriers such as major transportation routes or other infrastructure would more easily accommodate wetland migration. Also agricultural land that is no longer productive due to salt water intrusion may be lands that better accommodate future wetland migration. Areas identified as suitable for potential migration and the means to prohibit structures or obstructions in these areas should be thoroughly evaluated.

a. **Vulnerabilities addressed: Tidal and Freshwater Wetlands, Protected Lands Statewide, Habitats of Conservation Concern, Nature Preserves, Agricultural Land Conservation Easements, Residential Areas, Future Development Areas**
b. **Adaptation options addressed: Accommodate Avoid, Protect, Retreat**

50. **Encourage federal agencies to integrate sea level rise planning into their flood models.** The National Flood Insurance Program and Federal Emergency Management Agency do not currently include consideration for sea level rise in their floodplain models; floodplain models are based upon historic storm and flood data, rather than future projections. This results in floodplain maps that may underrepresent flood risk to residents. Delaware and other low-lying states can encourage the federal agencies to incorporate sea level rise into flood models and provide data and local knowledge for the development of floodplain maps that include sea level rise.
    a. **Vulnerabilities addressed: All**
    b. **Adaptation options addressed: Accommodate, Avoid, Protect, Retreat**

51. **Conduct research to better understand human response to sea level rise and adaptation.** People are the core of any adaptation decision and there currently are few studies about coastal residents' opinions of adaptation actions, thresholds for action or likely emotional responses to flooding and inundation issues. A better understanding of coastal residents' attitudes, perceptions and motivations could be very helpful in working with communities to choose adaptation options.
    a. **Vulnerability Addressed: All**
    b. **Adaptation Strategy Addressed: Accommodate, Protect**

52. **Improve the accuracy of Delaware's elevation benchmark network.** Delaware's network of benchmarks used for elevation surveys are currently inadequate due to lack of coverage in key coastal areas and problems with accuracy of existing benchmarks. Existing benchmarks should be re-surveyed and additional benchmarks created. This is necessary to ensure that adaptation projects in coastal areas are designed and constructed with accurate elevation data.
    a. **Vulnerability Addressed: All**
    b. **Adaptation Strategy Addressed: Accommodate, Protect, Retreat, Avoid**

53. **Continue and expand studies regarding sediment accretion rates and susceptibility of wetlands to sea level rise.** The state, University of Delaware and the National Estuary Programs have been working together to study and monitor sediment accretion rates and plant composition in Delaware's marshes in order to better understand survivability of certain marshes to inundation from sea level rise. Expanding this work to additional targeted locations across the state will provide a better data set from which to base land acquisition, restoration and retreat decisions.
    a. **Vulnerability Addressed: Wetlands**

   b. **Adaptation Strategy Addressed: Accommodate, Protect, Retreat**

54. **Add additional tidal observation stations in Delaware.** Variations in tidal levels in the Delaware Bay can be highly localized. The number and location of existing tidal stations in Delaware are inadequate to understand place-specific tidal conditions. A report entitled, "A Data GAP Analysis and Inland Inundation Survey for the Delaware Coastline (Leathers et al, 2010)," recommended additional stations in the vicinity of Slaughter Beach, Longneck, New Castle, Woodland Beach and Port Mahon.
    a. **Vulnerability Addressed: All**
    b. **Adaptation Strategy Addressed: Accommodate, Protect**

55. **Install inland inundation water level monitoring sites.** To better understand how tide levels on the coast equate to inland flooding and inundation, a series of inland water level monitoring stations is necessary. Such stations can help with understanding of extent and frequency of storm flooding in the short term while providing data and information useful for planning adaptation responses.
    a. **Vulnerability Addressed: All**
    b. **Adaptation Strategy Addressed: Accommodate, Protect**

Provide Technical Assistance to Partners for Assessing Vulnerability and Choosing Adaption Strategies

56. **Create a coordinated effort to provide technical assistance to local governments.** Municipal and county governments may not currently have the staff resources, technical capability or funding to plan for and adapt to sea level rise. There is no one coordinated entity that is providing coastal hazard and sea level rise assistance to municipal governments. Delaware Coastal Programs provides technical assistance and grant funding once a year. Delaware Sea Grant provides technical assistance through its Sustainable Communities Program. The Office of State Planning and Coordination provides technical assistance to communities conducting Comprehensive Development Plan revisions, as does the Institute for Public Administration. Delaware's Shoreline and Waterway Management Program provides assistance to communities to develop floodplain regulations and receive discounted flood insurance rates through the Community Ratings System. A coordinated effort by these (and other) entities could result in consistency between local jurisdictions and ensure that all municipal governments wishing to plan for coastal hazards and sea level rise can obtain the technical assistance they need. It could also result in coordinated grant funding opportunities for municipalities.
    a. **Vulnerabilities Addressed: All**
    b. **Adaptation Options Addressed: Accommodate, Avoid, Protect, Retreat**

57. **Provide land managers, fisheries managers and farmers with the information and extension support necessary to manage lands and fisheries in areas affected by sea level rise.** Technical assistance for land managers and agricultural producers is needed to disseminate information on salt water intrusion in irrigation wells, what plant species are salt tolerant, and best management practices (BMPs) for lands/wetlands in transition due to changes in water level or salinity. University extension agencies, or other established programs such as the Natural Resource Conservation Service, could be encouraged to provide this service. An additional goal might be to foster pilot projects to demonstrate or study the effectiveness of BMPs.

a. **Vulnerabilities Addressed: Tourism and Coastal Recreation, Wetlands, Habitats of Conservation Concern, Protected Lands, Ag Conservation Easements**
b. **Adaptation Options Addressed: Accommodate, Avoid, Protect, Retreat**

58. **Provide technical assistance for industrial and port facilities to incorporate sea level rise into investment plans and continuity of business plans.** Facilities often have robust continuity plans where they address interdependencies, but no inventory of these plans has been conducted. Sea level rise could be incorporated into these plans to ensure facilities are resilient to the impacts of storm surge coupled with sea level rise. Technical assistance could be provided through one-on-one outreach or through databases and information clearinghouses.
    a. **Vulnerabilities Addressed: Industrial Areas, Port of Wilmington**
    b. **Adaptation Options Addressed: Accommodate, Avoid, Protect, Retreat**

59. **Develop best management practice manuals for adaptation in Delaware.** Adaptation measures will be implemented by a variety of players including municipal and county governments, state government, businesses and individuals. A set of best management practices should be provided for their use and reference. Best management practice manuals could be created for several different subject areas including infrastructure siting, residential development, and natural lands management. Manuals should be based upon successful strategies employed by other states, non-profits and the private sector and could be developed in cooperation with local colleges and universities. A tool-box for adaptation could also be created that would highlight successful policies in other states.
    a. **Vulnerabilities Addressed: All**
    b. **Adaptation Options Addressed: Accommodate, Avoid, Protect, Retreat**

61. **Develop a database of costs of adaptation options for use by decision-makers and the public** Such a database should include example costs of: raising a building, beach replenishment, abandoning buildings, elevating roadways, building hardened shorelines, raising and repairing dikes, and living shorelines (soft shoreline restoration like grass planting). Cost estimates cannot be site specific but may be able to provide general guidelines. This database should also incorporate cost benefit analyses that would evaluate retreat, accommodation, avoidance and protection measures, including return on investment.
    a. **Vulnerability Addressed: All**
    b. **Adaptation Strategy Addressed: Accommodate, Protect, Retreat, Avoid**

Expand Funding Opportunities for Adaptation Planning and Implementation Projects

62. **Convene an expert panel to provide an assessment and analysis of funding options for adaptation.** At the current time, there is little specific information available regarding the potential cost of adaptation in Delaware. Because costs are not exactly known, it is difficult to recommend a particular course of action. An expert panel should be brought together to investigate the suite of options that are available to state and local governments, as well as individuals, to fund future adaptation options. Included in this analysis should be traditional revenue

generators such as taxes and fees, but it should also include innovative funding mechanisms such as special tax districts, incentives and cost-share programs. The analysis should utilize the preliminary funding options formulated by the Sea Level Rise Advisory Committee and public comments received during the Adaptation Engagement Sessions in February 2013 as a baseline. These comments are available in Appendix XX

a. **Vulnerability Addressed: All**
b. **Adaptation Strategy Addressed: Accommodate, Protect, Retreat, Avoid**